Reading for today: sec. 9.3.

CS1110. 17 Nov 2011 Ragged arrays

Reading for next time: Interfaces:
Sec. 12.1 and corresponding ProgramLive material. Also, compare with previous discussions of abstract classes (Sec. 4.7).

About recursion: Did you Hear about the programmer they found dead in the shower? He was clutching an empty bottle of shampoo which read, "Lather, rinse, repeat."

1. Slow to reveal!

```
/** Extract and return … */
public String reveal() {
  …

  int p= 4;
  String result= "";

  // inv: All hidden chars before
  // pixel p are in result[0..k-1]
  for (int k= 0; k < len; k= k+1) {
    result= result +
          (char) (getHidden(p));
    p= p+1;
  }
  return result;
}
```

gives n^2 algorithm (n is message length)

```
/** Extract and return … */
public String reveal() {
  …

  int p= 4;
  char[] result= new char[len];

  // inv: All hidden chars before
  // pixel p are in result[0..k-1]
  for (int k= 0; k < len; k= k+1) {
    result[k]=
          (char) (getHidden(p));
    p= p+1;
  }
  return new String(result);
}
```

linear algorithm

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Review of two-dimensional arrays

Type of d is **int**[][]

("**int** array array"/ "an array of **int** arrays")

To declare variable d:

int d[][];

To create a new array and assign it to d:

d= **new int**[5][4];

or, using an array initializer,

d= **new int**[][]{ {5,4,7,3}, {4,8,9,7}, {5,1,2,3}, {4,1,2,9}, {6,7,8,0} };

d	0	1	2	3
0	5	4	7	3
1	4	8	9	7
2	5	1	2	3
3	4	1	2	9
4	6	7	8	0

Some mysteries: an odd asymmetry, and strange toString output (see demo).

Number of rows of d: d.length

Number of columns in row r of d: d[r].length

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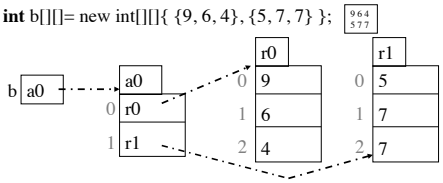
How multi-dimensional arrays are stored: arrays of arrays

int b[][]= new int[][]{ {9, 6, 4}, {5, 7, 7} };



b holds the name of a one-dimensional array object with b.length elements; its elements are the names of 1D arrays.

b[i] holds the name of a 1D array of **int**s of length b[i].length

java.util.Arrays.deepToString recursively creates an appropriate String.

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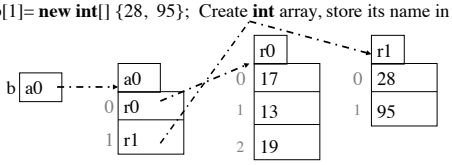
Ragged arrays: rows have different lengths

int[][] b; Declare variable b of type **int**[][]

b= **new int**[2][] Create a 1-D array of length 2 and store its name in b. Its elements have type **int**[] (and start as **null**).

b[0]= **new int**[] {17, 13, 19}; Create **int** array, store its name in b[0].

b[1]= **new int**[] {28, 95}; Create **int** array, store its name in b[1].



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Pascal's Triangle

```
                1                    0
              1   1                  1
            1   2   1                2
          1   3   3   1              3
        1   4   6   4   1            4
      1   5   10  10  5   1          5
                                     …
```

The first and last entries on each row are 1.

Each other entry is the sum of the two entries above it

row r has r+1 values.

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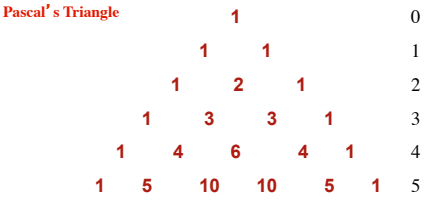
Pascal's Triangle



Entry p[i][j] is the number of ways i elements can be chosen from a set of size j !

p[i][j] = "i choose j" = $\binom{i}{j}$

recursive formula:
for $0 < i < j$, $p[i][j] = p[i-1][j-1] + p[i-1][j]$

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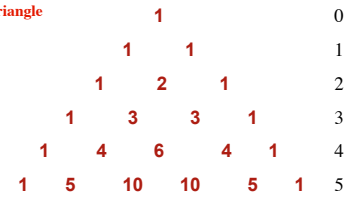
Pascal's Triangle



Binomial theorem: Row r gives the coefficients of $(x + y)^r$

$(x + y)^2 = 1x^2 + 2xy + 1y^2$

$(x + y)^3 = 1x^3 + 3x^2y + 3xy^2 + 1y^3$

$(x + y)^r = \sum_{0 \le k \le r}$ (k choose r) $x^k y^{r-k}$

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Function to compute first r rows of Pascal's Triangle in a ragged array

```
/** = ragged array of first n rows of Pascal's triangle.
    Precondition: 0 ≤ n */
public static int[][] pascalTriangle(int n) {
    int[][] b= new int[n][];     // First n rows of Pascal's triangle
    // invariant: rows 0..i-1 have been created
    for (int i=  0; i != b.length; i=  i+1) {
      // Create row i of Pascal's triangle
        b[i]= new int[i+1];
      // Calculate row i of Pascal's triangle
        b[i][0]=  1;
        // invariant b[i][0..j-1] have been created
        for (int j= 1; j < i; j= j+1) {
          b[i][j]=  b[i-1][j-1] + b[i-1][j];
        }
        b[i][i]= 1;
    }
    return b;
  }
```

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Adding up elements of an Integer or int array no matter what its dimension!!

```
/** = Sum of elements of b.
      Precondition: b is an Integer or an array with base type Integer. */
public static int sum(Object b) {
    if (b instanceof Object[]) {
      Object[] bb= (Object[]) b;
      int sum= 0;
      //inv: sum = sum of b[0..k-1]*/
      for (int k= 0; k < bb.length; k= k+1) {
        sum= sum + sum(bb[k]);
      }
      return sum;
    }

    // { b has type Integer }
    return 0 + (Integer) b;
}
```

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